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The Measurement of Refraction by the Shadow-Test or Retinoscopy.

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THE MEASUREMENT OF REFRACTION BY THE SHADOW-TEST, OR RETINOSCOPY.

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Ten years ago Cuignet, of Lille, had described a form of this test, calling it *keratoscopie*; but his paper upon the subject seems to have made no change in the methods of practical ophthalmologists. In 1878, however, his pupil, Dr. Mengin, introduced the practice of the method at Galezowski's clinic, in Paris. Here it was taken up by Dr. Parent, who demonstrated its optical basis, described a method of using it, and urged its advantages in a series of articles published in the *Recueil d'Ophthalmologie*, 1880. The name keratoscopie was given on the supposition that the play of light and shade, with which the test is specially concerned, was solely dependent on the form of the cornea. Parent, finding that this play was really due to the movement of an area of light on the pigment layer of the retina, called the method *retinoscopie.* In this he erred in giving a name equally applicable to other ophthalmoscopic examinations. The name best descriptive of the test is probably *fantoscopie retinienne*, proposed by Chibret.

Priestley Smith has called it the shadow-test, and Hartridge proposes umbrascopy. Both names are brief and distinctive; but retinoscopy has been so far sanctioned by use that, probably, it will not be replaced by any other term. Keratoscopy must be dropped. It is misleading, as is well illustrated by the reference to Charnley's paper, to be found in the *Index Medicus*, under the head of "Diseases of the Cornea."

In 1881, Parent spent some time at the Royal London Ophthalmic Hospital, and introduced the test there. It had already been noticed by Forbes (*Roy. Lond. Oph. Hosp. Rep.*, 1880, p. 62); but only after the visit of Parent did English ophthalmologists take it up with apparent

enthusiasm; Charnley giving a description of it, and the fullest demonstration of its optical basis, in the *Royal London Ophthalmic Hospital Reports* (1882, p. 344), Morton describing it in his work on Refraction, and Juler in the *Ophthalmic Review* (1882, p. 327), and in the *British Medical Journal* (1882, ii. p. 670). Since then a considerable number of ophthalmic surgeons resident in London, or more or less intimately connected with the professional life of that metropolis, have written to urge the advantages of the shadow-test; and it has taken a prominent place in the text-books emanating from this medical centre. See those by Morton, Hartridge, Juler, Swanzy, and the late editions of MacNamara and others. The same thing might be said of Paris, and the literature emanating from its ophthalmologists and their intimate associates. But elsewhere this method of measuring refraction has scarcely been alluded to; and I have been able to find but a single brief and inadequate description of it that has been published on this side of the Atlantic. This neglect of the shadow-test is not without parallel. Other means of exact diagnosis, now generally employed, have made the same slow progress to professional favor. I am informed that it was not until about 1870 that ophthalmologists of this city began, habitually, to examine the fundus by the direct method. A description of the ophthalmoscope did not appear in this Journal until 1853, and then only as a quotation from an article published in a foreign journal; and it was not until eight years later that there appeared in these pages the recorded results of an ophthalmoscopic examination made by an American surgeon. How strangely these instances contrast with the mushroom-like growth of a literature pertaining to therapeutic measures, such as the use of jequirity or cocaine!

With regard to the shadow-test, there is special reason for its slow adoption, in that the refraction of most eyes can be accurately measured by methods already in general use. Then its advocates have nearly all described its application with the concave minor; a form of the test comparatively complex in theory and tedious in application, and, hence, offering the minimum of advantage from the maximum of effort spent in acquirement. The text-books and journal articles, above referred to, all describe this form of the test.

In 1882, Dr. Chibret published, in the *Annales d'Oculistique* (vol. xxxviii. p. 238), an article on the "Determination Quantitative de la Myopie par la Keratoscopie (Fantoscopie Retinienne), à l'Aide d'un Simple Miroir Plan," which set forth the advantages of the shadow-test with the plane mirror, in determining the presence and degree of myopia in the examination of large numbers of recruits. In the *Ophthalmic Review* for August, 1883 (p. 228), appeared John B. Story's article on "The Advantages of the Plane Ophthalmoscopic Mirror in Retinoscopy." Story seems to have commenced to use the plane mirror before the appearance of Chibret's paper; but he failed to appreciate and embody in the

method he described the greatest advantage of the shadow-test with the plane mirror, namely, the capacity to determine exactly the kind and amount of ametropia with but one or two changes of the lens placed before the patient's eye.

Finally, Priestley Smith has, in the *Ophthalmic Review* (1884, p. 266), described "A Simple Ophthalmoscope for the Shadow-test," and given some valuable hints as to the method of its use. Though the special form of the shadow-test developed below has, I believe, never before been described, suggestions of its essential features may be found in these three papers by Chibret, Story, and Smith.

Method of Examination.—The patient, with his accommodation at rest, is placed in the dark room, with the source of light just above his head, and far enough back to leave his face in shadow. He is told to look at the observer's forehead. The observer stands in front of the patient armed with a plane mirror; the simplest form being a piece of looking-glass one inch wide, three inches long, with the silvering scraped from two-thirds its length, and a hole three millimetres in diameter at the centre of the square that remains. With this mirror the light is reflected upon the patient's eye and face. Now, by rotating the mirror to the right about its vertical axis, the area of light upon the patient's face (facial area) is made to move to the right; by rotating it in the opposite direction, the facial area is moved to the left. By rotating it in other directions about other axes, the facial area may be made to move upward or downward, either vertically or at any oblique angle. Now the light which falls on the pupil passes back and forms on the pigment coat of the retina a second smaller area of light, the retinal area. This retinal area, it can be readily demonstrated, moves when the facial area moves, and always "with" it, that is, in the same direction. But the observer, by placing his eye at the central aperture of his mirror, can study in the patient's pupil the direction of the apparent movement of this retinal area. This will correspond to the direction of real movement when an erect image is viewed, but will be the opposite of the direction of real movement when an inverted image is under inspection. Hence, the *real* movement of the retinal area being always with the facial area; when the *apparent* movement of the retinal area is with the facial area, the fundus is perceived in the erect image; when the apparent movement of the retinal area is against the movement of the facial area, the fundus is perceived in the inverted image. So much for the optical basis of the test. Let us now consider its practical application in the various states of refraction.

Simple Myopia.—Rays of light from any given point of the retina emerge from the myopic eye convergent, and meet at the point in front of the eye, for which the eye is optically adjusted. The accommodation being in abeyance, this will be the far point of distinct vision. So that

there is formed at the far point of the myopic eye an inverted image of the retina. If now the eye of the observer be placed between the patient's eye and its far point, there will be seen an erect image of the patient's retina; but if the observer view the patient's eye from somewhere beyond its far point, he will see, not an erect image, but the inverted image formed at that far point. In the first case the boundary of light and shade which marks the border of the retinal area will appear to move with the facial area; in the second case, against it. In practice the surgeon begins the examination somewhat more distant from the patient than the far point of the eye under examination. Then he slowly approaches the patient, all the while watching the apparent movement of the retinal area produced by slightly rotating the mirror from side to side about its axis. As long as this apparent movement is opposed to that of the facial area, the surgeon knows he is watching the inverted image at the patient's far point. Presently, however, the direction of the movement of the retinal area cannot be distinguished, the far point has now been reached; and coming still closer the apparent movement again becomes distinct, but is seen to correspond in direction with the real movement, the far point has now been passed, and the patient's retina is being viewed in the erect image. By noting the point at which this reversal occurs, the surgeon notes the far point of the eye under observation; by measuring the distance from this point of reversal to the eye, he measures the distance from the patient to his far point of distinct vision; and the reciprocal of this distance, of course, expresses the degree of his myopia. Thus, supposing the point of reversal to be one-fourth of a metre in front of the eye, one divided by one-fourth equals four, the number of dioptres of myopia present.

Theoretically, the method as now described is complete, but for convenience and accuracy in its application, one or two other points must be attended to. When the observer's eye has come quite close to the patient's, say to within one-eighth of a metre, and the inverted image is still seen between them, it is best to place a concave lens (—8. D) before the patient's eye, and then to estimate the amount of myopia remaining uncorrected; and by adding it to the amount which the lens used has corrected, determining the total myopia present. When the observer has approached so near the inverted image that it lies closer to his eye than his near point of distinct vision, he can no longer see that image distinctly. Still he can distinguish in which direction the retinal area appears to move, until he approaches somewhat nearer to the image, when the circles of diffusion upon his own retina become so large that the retinal area of light, seen in the patient's pupil, seems very diffuse and faint, and the direction of its apparent movement uncertain. Because of this, there is great practical difficulty in determining exactly where the point of reversal is situated. Now it is evident that if the point of reversal

is within a few inches of the eye, an error of two or three inches as to its position entails an error of some dioptres in the amount of myopia present. Therefore, when by the method above described the degree of myopia has been approximately ascertained, place before the patient's eye a concave lens strong enough to remove the point of reversal a metre or more from the eye. At such a distance, an error of two or three inches as to the position of the point of reversal is of no consequence; and an accurate determination of the remaining, and hence of the total myopia, can readily be made. Having determined the amount of myopia present, the surgeon will of course be guided by the rules he would follow had the myopia been measured by any other method.

Hypermetropia.—On viewing the fundus reflex it is found that at all distances the erect image is seen, and the retinal area appears to move with the facial area. Place before the patient's eye a convex lens strong enough to over-correct the hypermetropia. Then, by the method given above, determine the degree of myopia so produced. Deduct this amount of myopia from the strength of the convex lens used; and the remainder will express the degree of hypermetropia present. Suppose, for example, the hypermetropia amounts to four dioptres. Placing a five dioptre convex lens before the eye it is found that one dioptre of myopia is produced, the point of reversal being at one metre. Then five, minus one, equals four, which expresses in dioptres the amount of hypermetropia present. Should it be found that the + 5 . D. lens leaves the eye hypermetropic so that the erect image is seen at all distances, replace it by a + 10 . D., and proceed as before. As in myopia, however, the final accurate determination should be made at a distance of not less than one metre. It may be noticed that low degrees of myopia may be measured without the use of any lens, but that to determine the degree of hypermetropia present, a convex lens is always necessary.

Emmetropia is determined by the method for measuring hypermetropia. The convex lens being placed before the eye, the resulting myopia is found to equal exactly the strength of the lens in use.

Regular Astigmatism.—In applying the test to the measurement of regular astigmatism, instead of rotating the mirror about any axis, vertical, horizontal, or oblique, as may be done when the curvature of the cornea is the same in all directions, it is rotated about axes perpendicular to the directions of the principal meridians of curvature, and the point of reversal thus found for each principal meridian. To determine the direction of these principal meridians, the eye, if not previously so, should be rendered myopic in all meridians, and then viewed from different distances. It will then be found that at certain points the fundus reflex takes the shape of a more or less distinct band of light stretching across the pupil, while on one or both sides of it may be seen a shaded area, "the somewhat linear shadow" of Bowman. This band of light is very

readily moved in a direction perpendicular to its length, but in the direction of its length cannot be made to move at all. The point where this appearance is presented is the point of reversal for that principal meridian of the cornea, whose direction coincides with the length of the band. The other principal meridian is, of course, at right angles to this; and the observer by placing his eye at its point of reversal will be in position to see a similar band extending in a direction perpendicular to that of the band first observed. This use of the shadow-test may be made clearer by the consideration of what occurs in a particular case. Suppose the patient's cornea to have such a curvature as to cause in the horizontal meridian (axis vertical) a hypermetropia of four dioptres, and in the vertical meridian (axis horizontal) a myopia of one dioptre. Place before the eye a + 5 . D. spherical lens. On approaching it from a distance, it is found that the retinal area moves against the facial area in all directions. But as the distance of one metre is approached, it is noticed that the retinal area takes the form of a horizontal band, readily movable upward or downward, but difficult to move to the right or left; and when the point of one metre is reached, all movement to the right or left ceases, and the band is most distinct. Going still closer, the point of reversal for the horizontal meridian being passed, movement to the right or left reappears, but it is now with the facial area. The movement upward or downward is still against that of the facial area. As the patient is still approached, the appearance of a horizontal band fades out, and presently is replaced by that of a vertical band. The vertical band moves readily to the right or left, but less distinctly upward or downward, and at one-sixth of a metre all vertical motion is lost. This is the point of reversal for the vertical meridian. On approaching still closer, vertical movement reappears, but like the horizontal movement it is now with the facial area, not against it. Thus it is found that for the horizontal meridian the point of reversal is one metre distant from the eye, and that for the vertical meridian the point of reversal is one-sixth metre distant. That is, the use of the convex lens has made the eye myopic in the one meridian one dioptre, in the other meridian six dioptres; and by taking into account the effect of the spherical lens used, the mixed astigmatism is seen to be what we supposed it. But for accurate work, as in simple myopia and hypermetropia, the degree of ametropia for each meridian should be finally determined with such a lens before the eye as would place the point of reversal, for that meridian, one metre or more distant.

The apparent form of the fundus-reflex, its brightness and rapidity of movement are matters of very little importance in connection with the shadow-test, as I have endeavored to describe it; except in the case of astigmatism. Of regular astigmatism I have spoken. Of *irregular astigmatism*, it may be said that it gives to the fundus reflex forms infinitely numerous. Two only need be mentioned here, the central bright point

and shaded circle by central illumination, changing to a light and a shaded area, separated by a boundary angular at the centre of the cornea, when the mirror is turned, which has long been known to indicate conical cornea; and a bright circle at the margin of the pupil, with a fainter central area, which indicates curvature of the crystalline lens, greater towards the margin than near the centre of the pupil. Generally this condition exists, if the pupil be fully dilated, and the effect is puzzling to one unpractised in the shadow-test, because the ring or crescent at the edge of the pupil reverses closer to the eye than does the image at the centre of the pupil; and the latter reversal, though less striking, is the one of practical importance. The danger of the error being recognized, however, it will, after a little practice, be readily avoided. Although the presence of irregular astigmatism thus makes the shadow-test somewhat more difficult of application, the test in certain cases, as in the "facetted" cornea, certainly affords the best means of measuring the general state of refraction. It is a point of practical importance that the appearance of the fundus-reflex also depends on the shape, size, and practical distance of the source of light; the practical distance of the source of light being the distance from the light to the mirror, plus the distance from the mirror to the patient's eye. A large irregular flame, close to the patient's eye, will not give the band-like appearance characteristic of regular astigmatism; this appearance being presented only in so far as the source of light approximates to the condition of a mathematical point. On the other hand, the source of light must not be so small that the fundus-reflex will entirely disappear when the light is reflected to the patient's eye from the region of the central aperture in the mirror.

The advantages of the shadow-test, as above described, are, that it is most widely applicable, has the certainty of an objective method, the accuracy of trials with test-lenses, and the rapidity of the optometer. It is applicable in the cases of young children, the amblyopic and malingerers, in which subjective tests cannot be used; and in cases where restlessness, nystagmus, hazy media, or the loss of the other eye, render accurate examination in the erect image by a refraction ophthalmoscope difficult or impossible. In certainty, when the patient retains the power of accommodation, it seems to me inferior to the "direct method" as a means of discovering and measuring latent hypermetropia. But it is superior to the direct method in the detection and estimation of astigmatism.

Assuming that the amount of regular astigmatism does not vary, by reason of unequal contraction of the ciliary muscle, quite low degrees of it (less than a half dioptre) can be recognized, measured, and the axis fixed, in the face of varying accommodation. Again, the shadow-test is free from any possibility of error due to the observer's unconscious accommodation; and this seems to me no small matter, at least for young

observers. I know there are times when, after taxing my own eyes with close work, a certain error of unconscious accommodation vitiates my work with the refraction ophthalmoscope. The shadow-test avoids this entirely. Charnley has stated (*loc. cit.*, p. 357) that "the observer, if not emmetropic, must correct his ametropia," and the error is perpetuated in the American description of the shadow-test, as practised in English hospitals. (A. R. Baker, Retinoscopy, *Am. Journ. of Ophthalmology*, vol. i. p. 116.)

The observer's ametropia only interferes with the use of the shadow-test when it prevents him from seeing, with sufficient clearness, objects a few feet distant. In accuracy, the test in my experience very nearly equals the subjective test with trial lenses for patients who have good vision, good intelligence, and honesty; for patients lacking in any of these requisites for subjective testing, it is markedly more accurate than any other method. In all cases where the state of refraction is to be measured accurately, it effects a saving of time; in the stupid or sluggish this saving is very great.

The shadow-test may be looked upon as the union and evolution of two modes of examination almost as old as the ophthalmoscope itself, namely, the twirling of the mirror to detect conical cornea, and the examination of the myopic eye by the indirect method, without the intervention of an object lens. Those who desire to study more minutely the history of that evolution, and to assign due credit to those who have aided in the process, will find the appended references a valuable addition to those already given in the text.

Wm. Bowman, Paper on Conical Cornea, Roy. Lond. Oph. Hosp. Reports, vol. ii. p. 157. *F. C. Donders*, Accommodation and Refraction, London, 1864, pages 106, 490, and 551. *John Couper*, The Ophthalmoscope as an Optometer in Astigmatism; Report of the Fourth International Ophthalmological Congress, London, 1872, page 109. *E. G. Loring*, Determination of the Refraction of the Eye with the Ophthalmoscope, New York, 1876, pages 47–51.